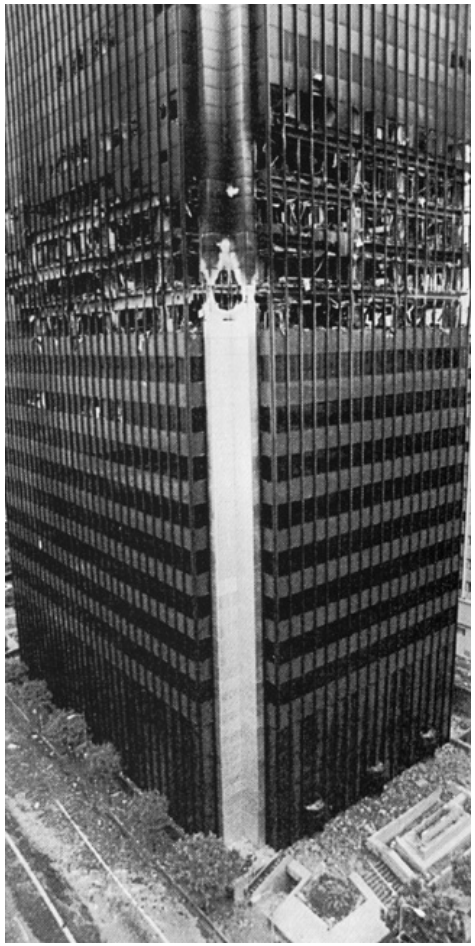
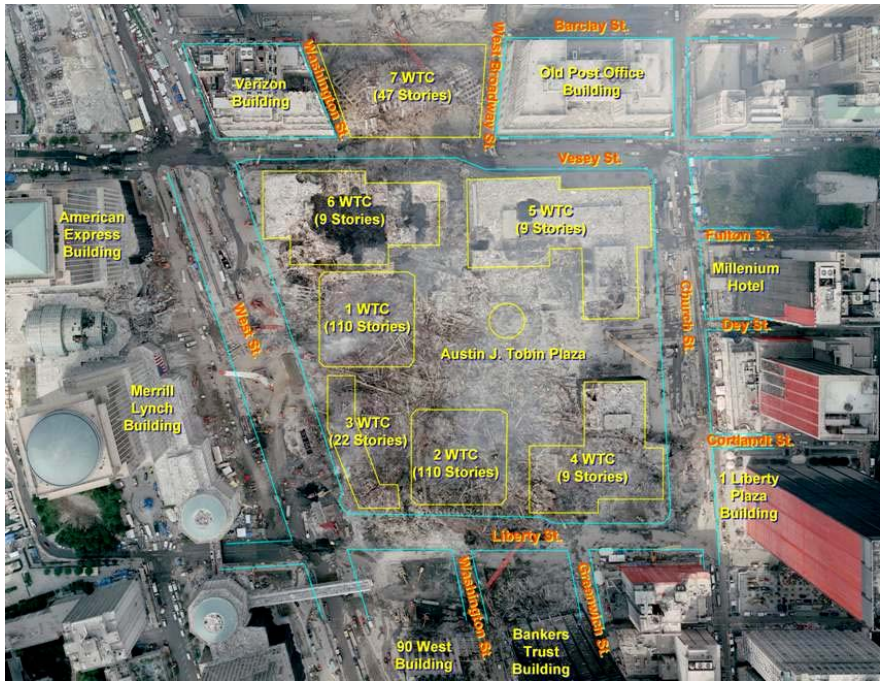
10:30 – 12:30	**<u>Fire Structure Interaction</u> (Chair: *K. Prasad, NIST*)**
10:30 am	Experimental Study on the Behavior of Composite Steel Frame Subjected to Fire ***Y. Dong & K. Prasad, Harbin Inst. Tech. & NIST***
10:50 am	Structural Behavior and Stability under Fire Loading ***A. Varma et al., Purdue U. & NIST***
11:10 am	Real Time Monitoring of Burning Structures ***Z. Duron, Harvey Mudd College***
11:30 am	Behavior and Capacity of Steel Perimeter Columns in a High-Rise Building under Fire ***M. Garlock & S. Quiel, Princeton U.***
11:50 am	Numerical Study of Concrete Thermal Spalling and Application of Simplified Analysis of Fire-Induced Progressive Collapse. ***J. Chung & T. Krauthammer, U. Florida***
12:10 pm	A Tool for the Prediction of Structural Behavior in Fires ***D. Dat et al., NIST***
12:30 pm	**Lunch, NIST Cafeteria**



Interstate Bank Building Fire
Los Angeles, CA 1988



WTC Tower
New York,
2001.

Windsor Tower, Spain, 2005

East Tower Central Park,
Venezuela, 2004

An Experimental Study on the Behavior of Full-Scale Composite Steel Frames under Furnace Loading

Yuli Dong

School of Civil Engineering, Harbin Institute of Technology, China

Kuldeep Prasad

National Institute of Standards and Technology, Gaithersburg, MD, USA

Motivation

- Behavior of isolated structural members.
  - Fire Safety Design
  - Interaction between adjacent members, connections?
  - Performance of real structures can be different?
  - Heat up and cool down phase?

- World Trade Center Investigation
  - Mathematical and Numerical Models
  - Lack of experimental data

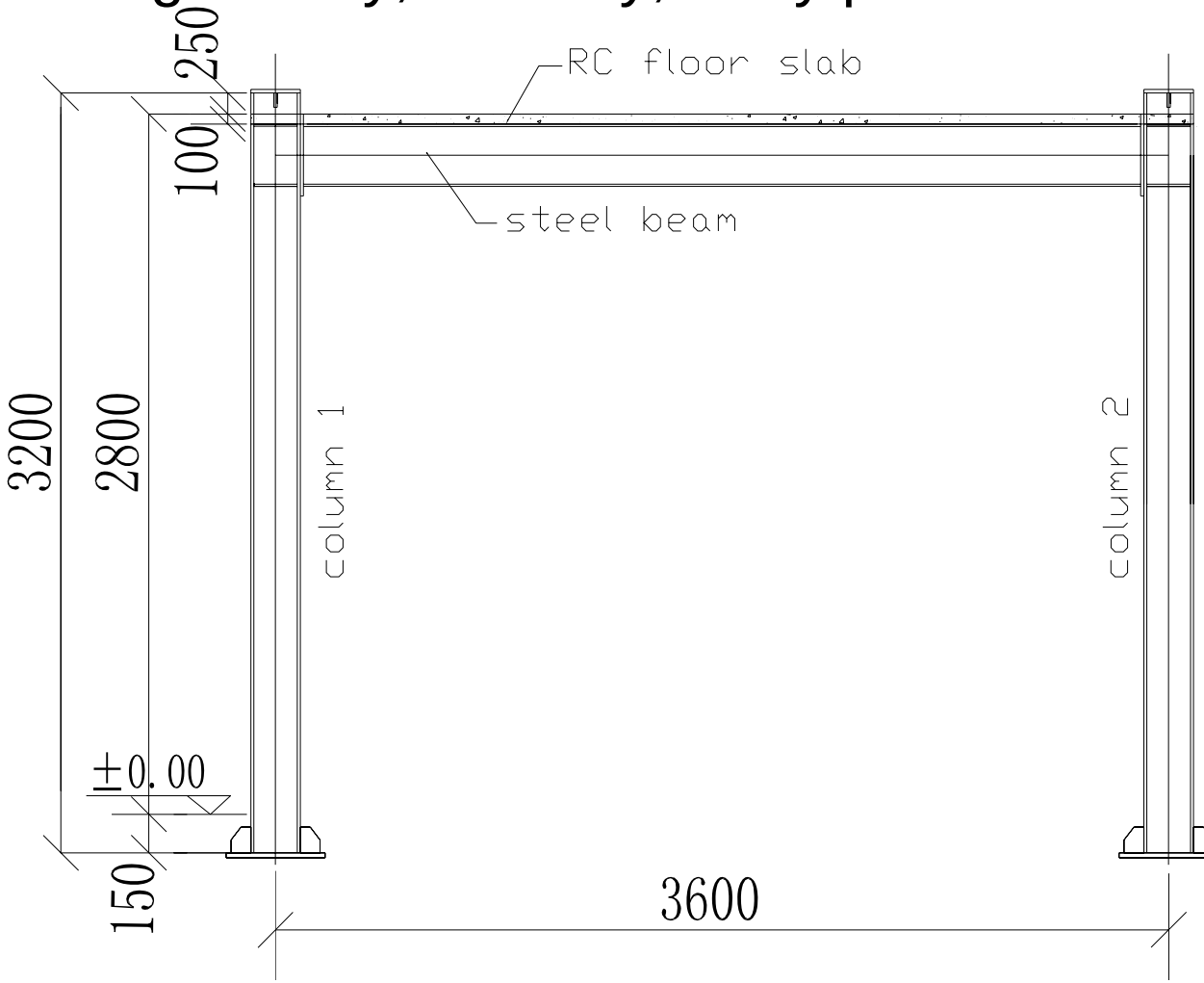
- Structures in Fire Conference (SiF’06)
  - Brainstorming session
  - Need for experimental data on large scale structures under fire loading.

Approach

- Perform experiments on large scale structures under fire loading.
  - Develop understanding of the underlying physics.
  - Develop a database for validation of numerical models.
- Full-scale composite steel frames
  - Frame construction, Furnace test, Instrumentation.
  - Temperature data, transducer displacement
  - Visual observation of the failure modes.
  - Compare and contrast the furnace tests.

Frame Construction :

Single Story, one-bay, sway portal frame.



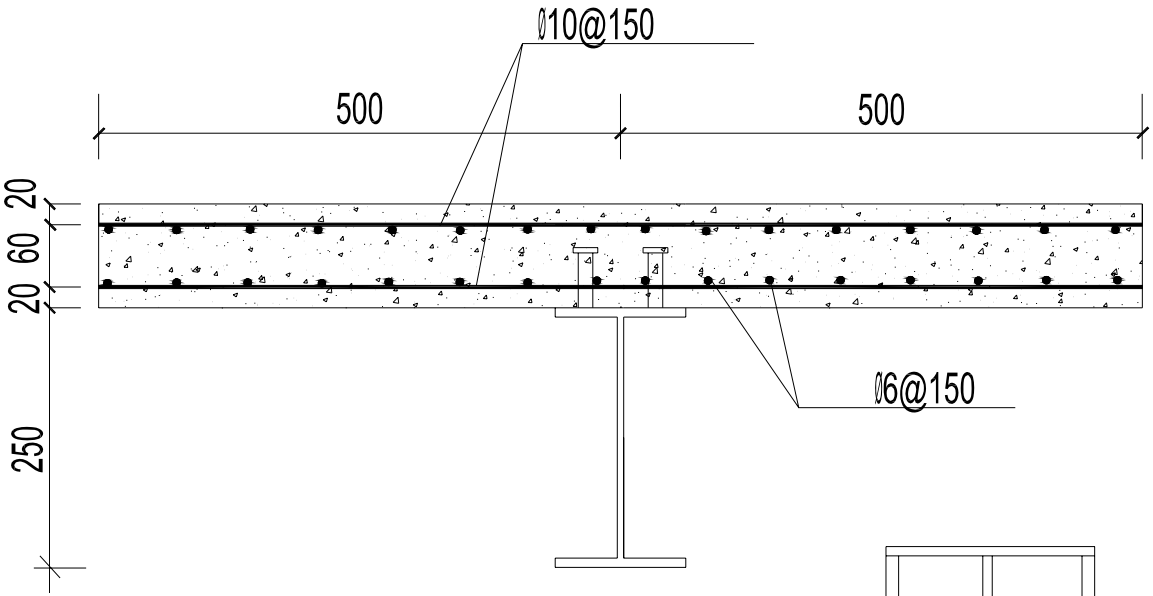
Columns : Q 235 Steel
H section (H200x200x8X12)

Steel Beam : Q 235 Steel
H section (H250x125X6X9)

Concrete slab :
NWC 30-40 MPA

Column base welded to a 16 mm steel plate which was bolted to the test bed.

Frame Construction



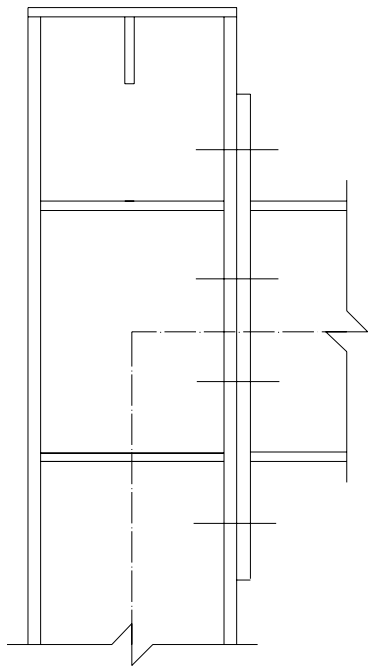
Composite beam section.

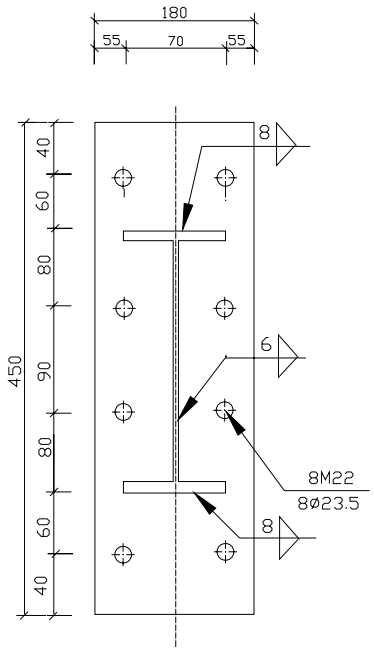
Anti-crack rebars

Longitudinal bars.

Composite floor behavior

Shear studs.



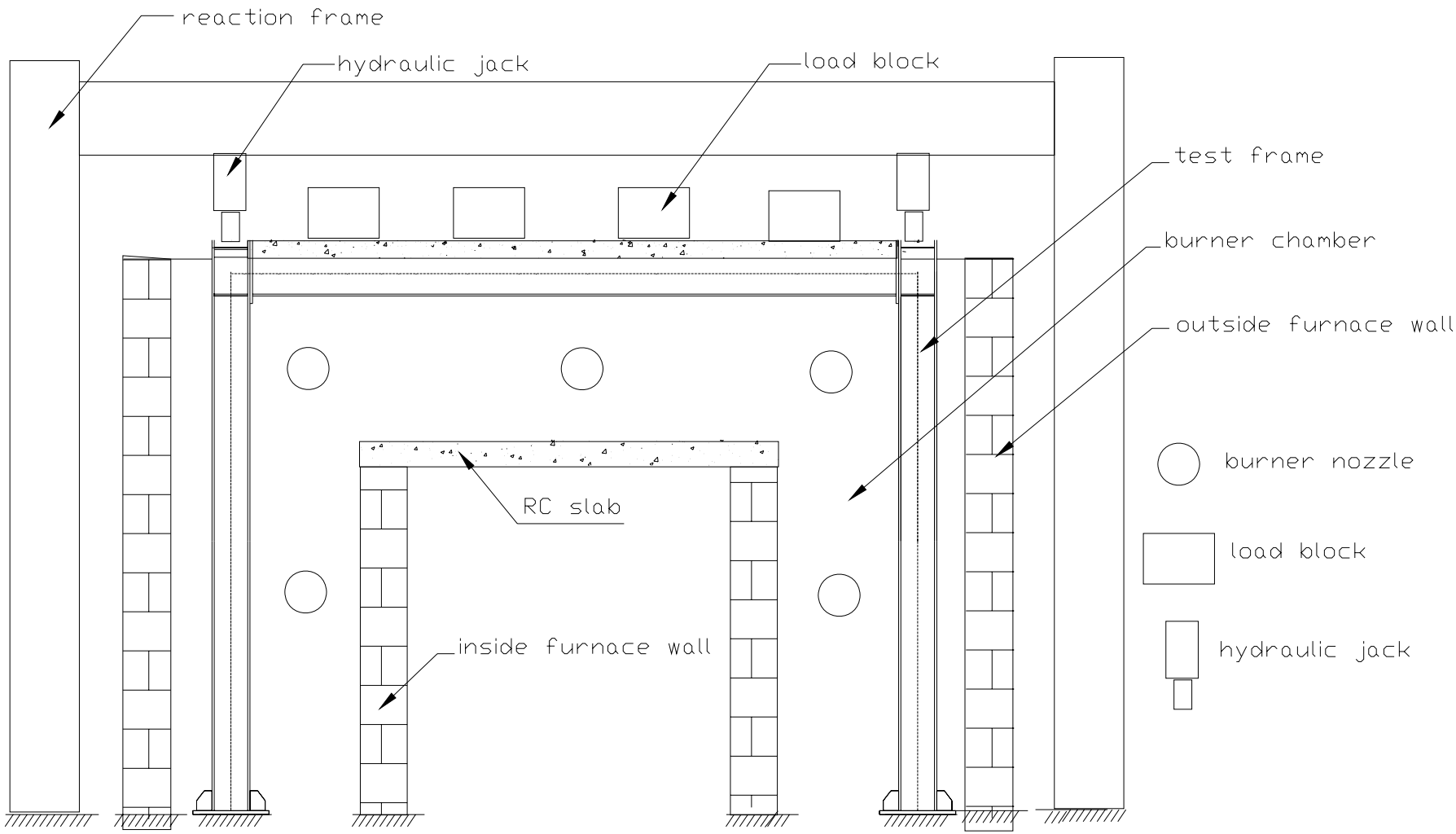


Beam to column connection

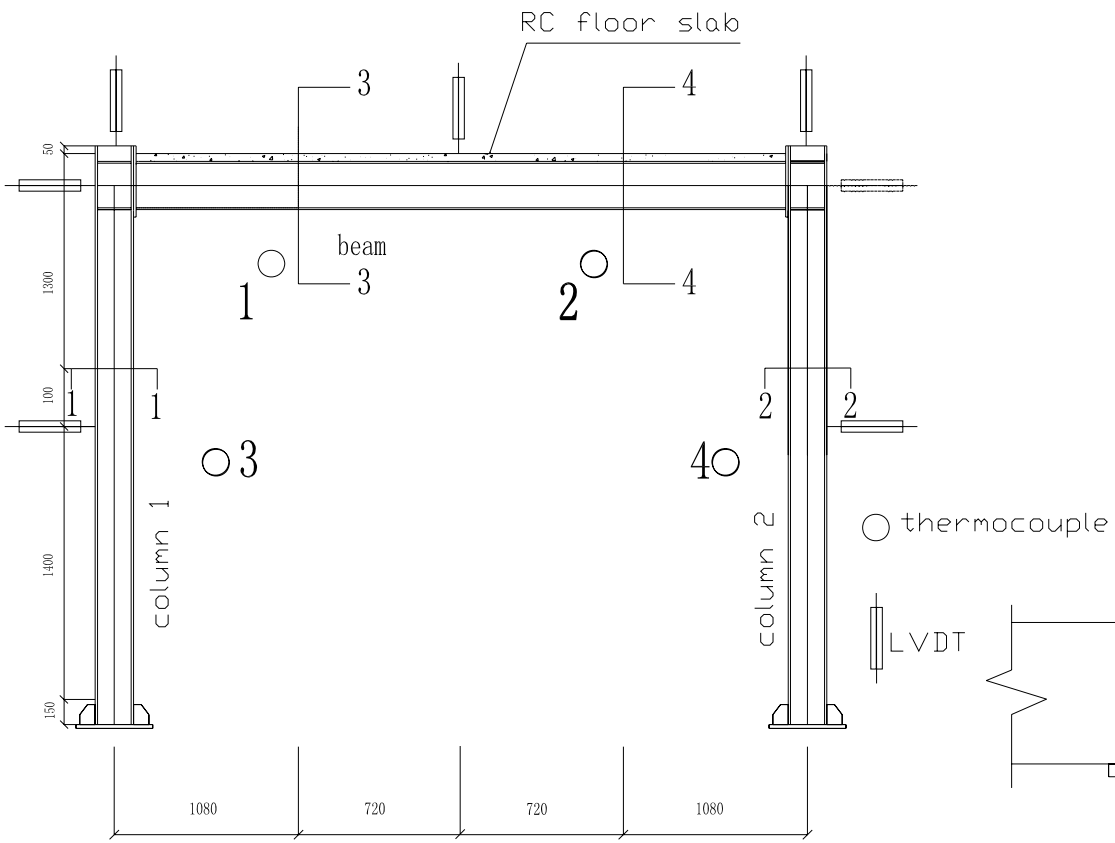
Designed to transfer both moment and shear forces.

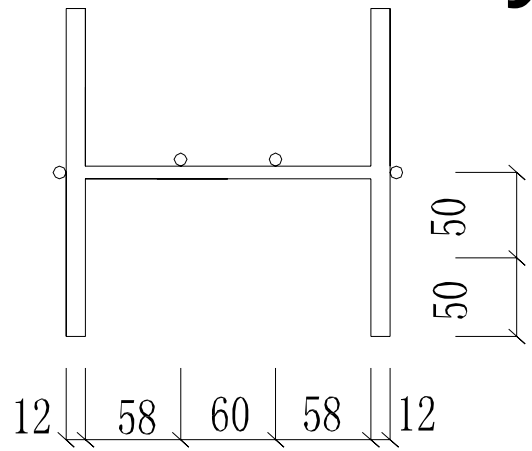
12 mm thick extended-end plate bolted with eight M22 grade 10.9 mm bolts.

Furnace Test Set up
Elevation View

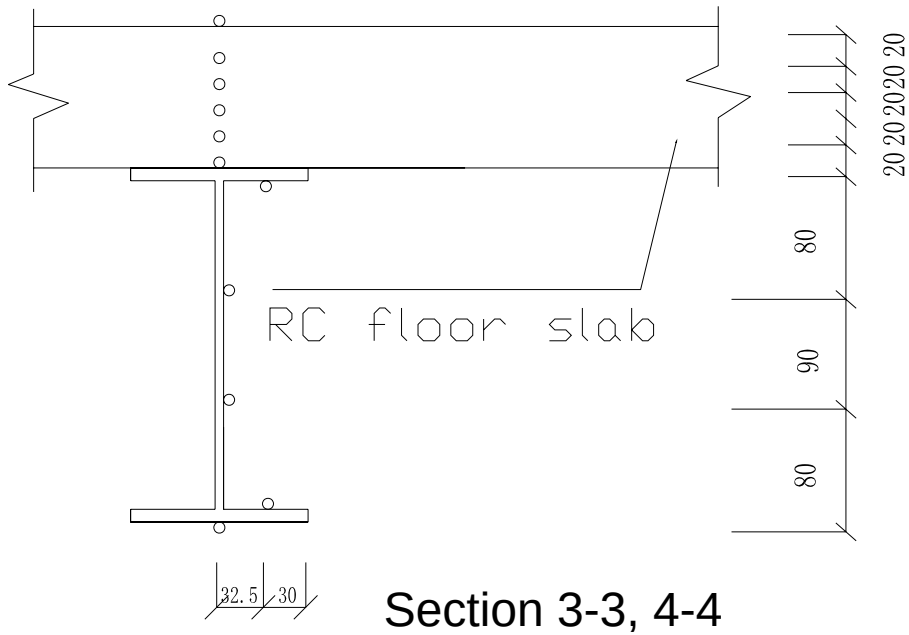


Instrumentation of test assembly



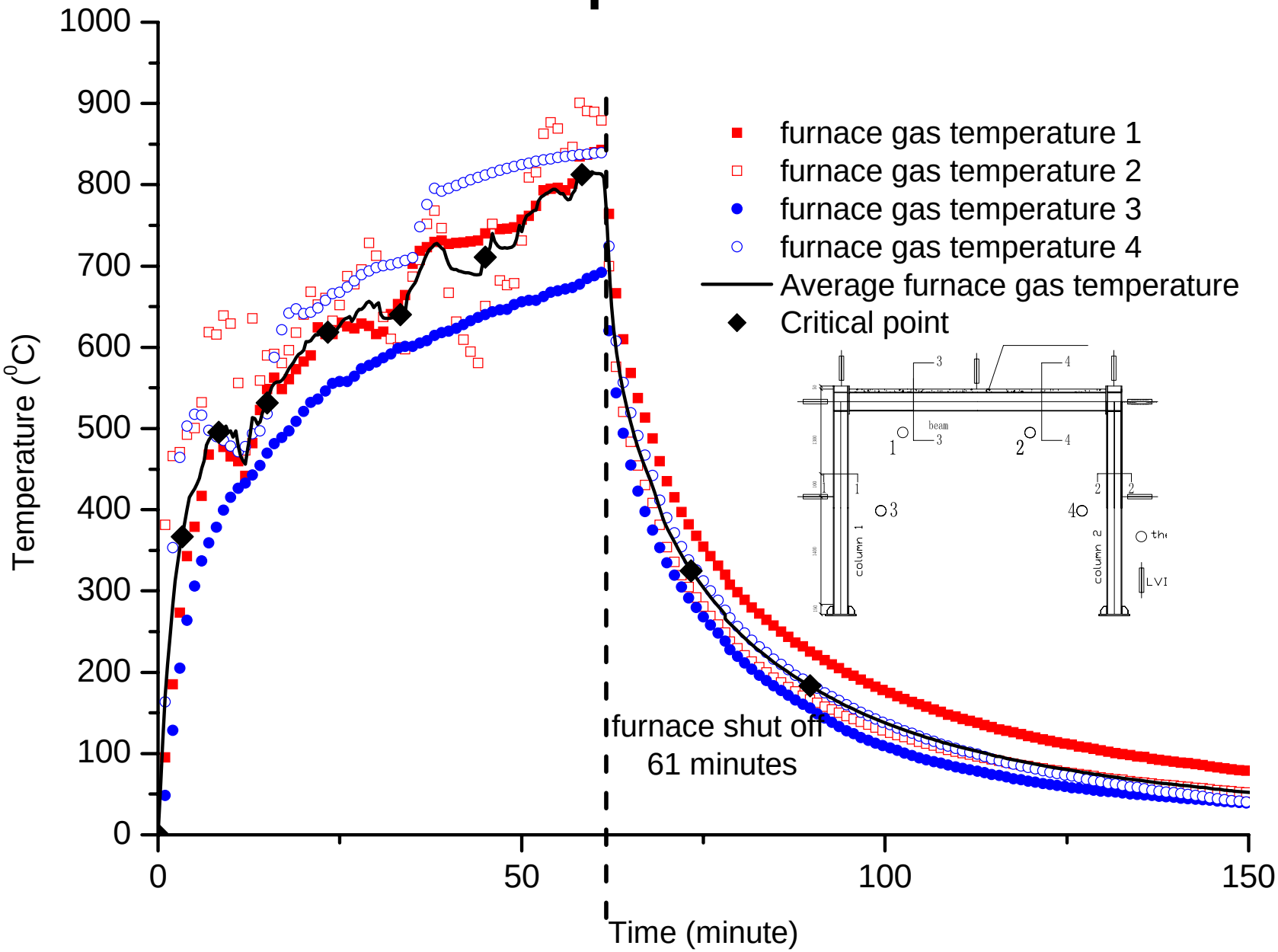


Section 1-1, 2-2

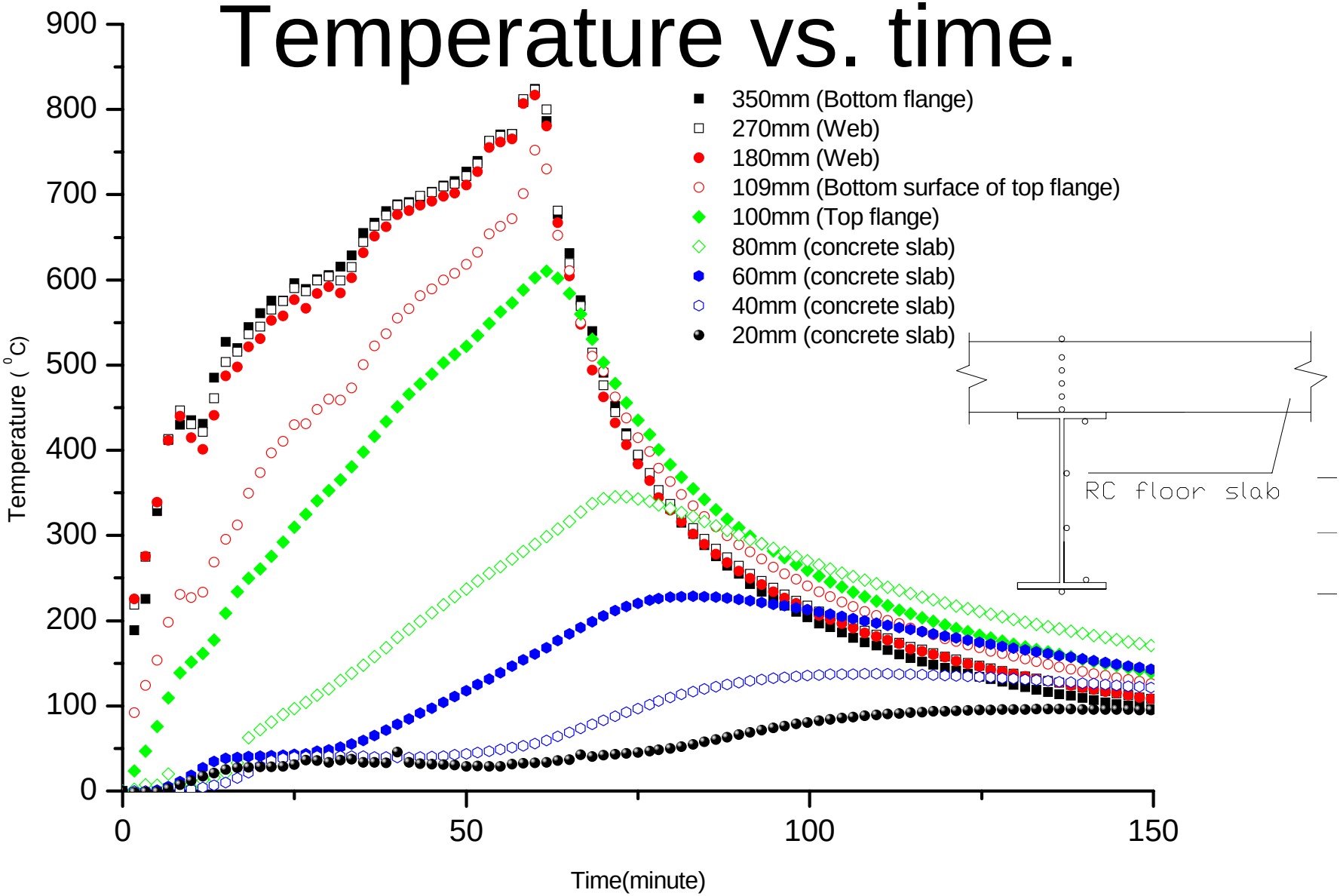


Section 3-3, 4-4

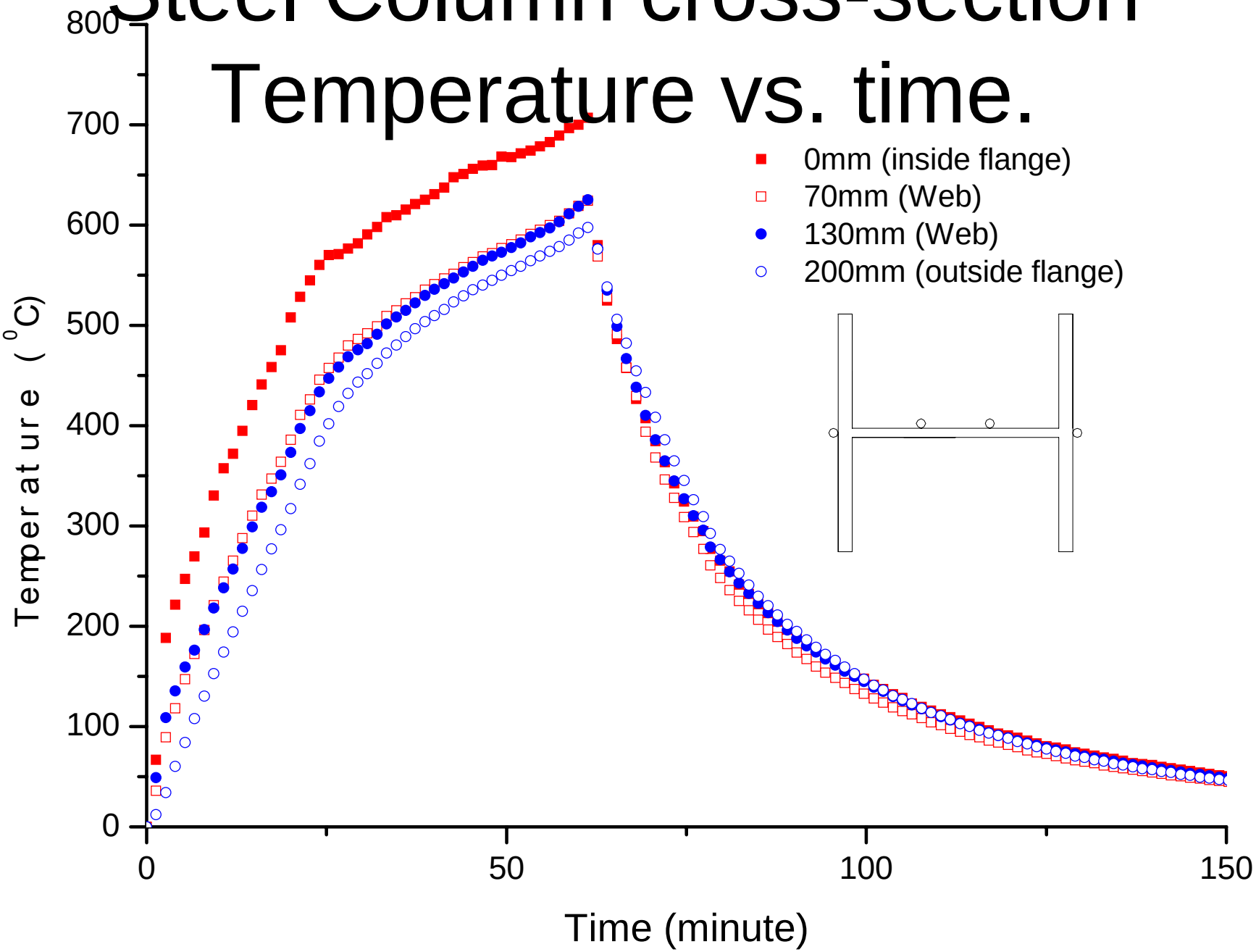
Furnace temperature vs. time

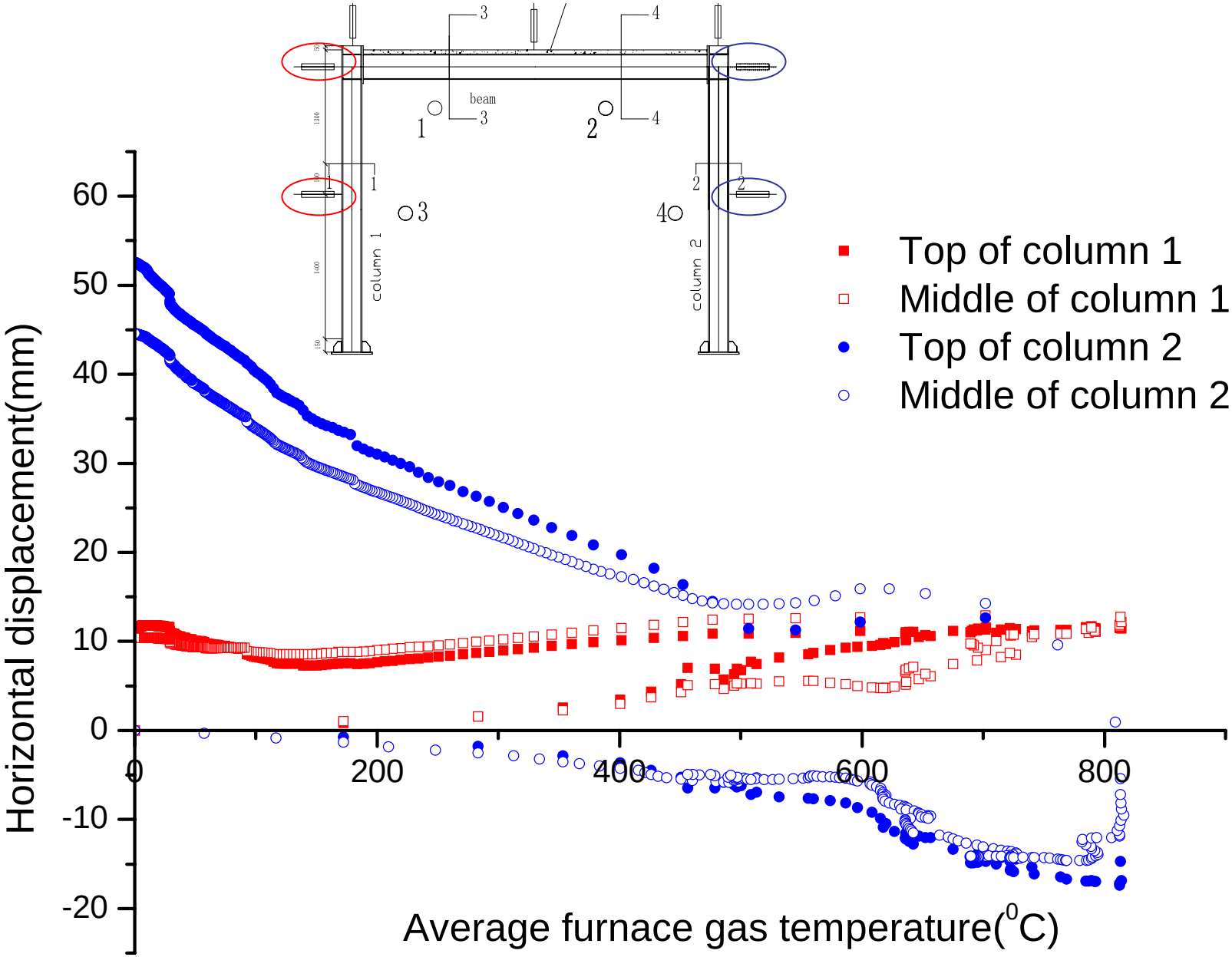


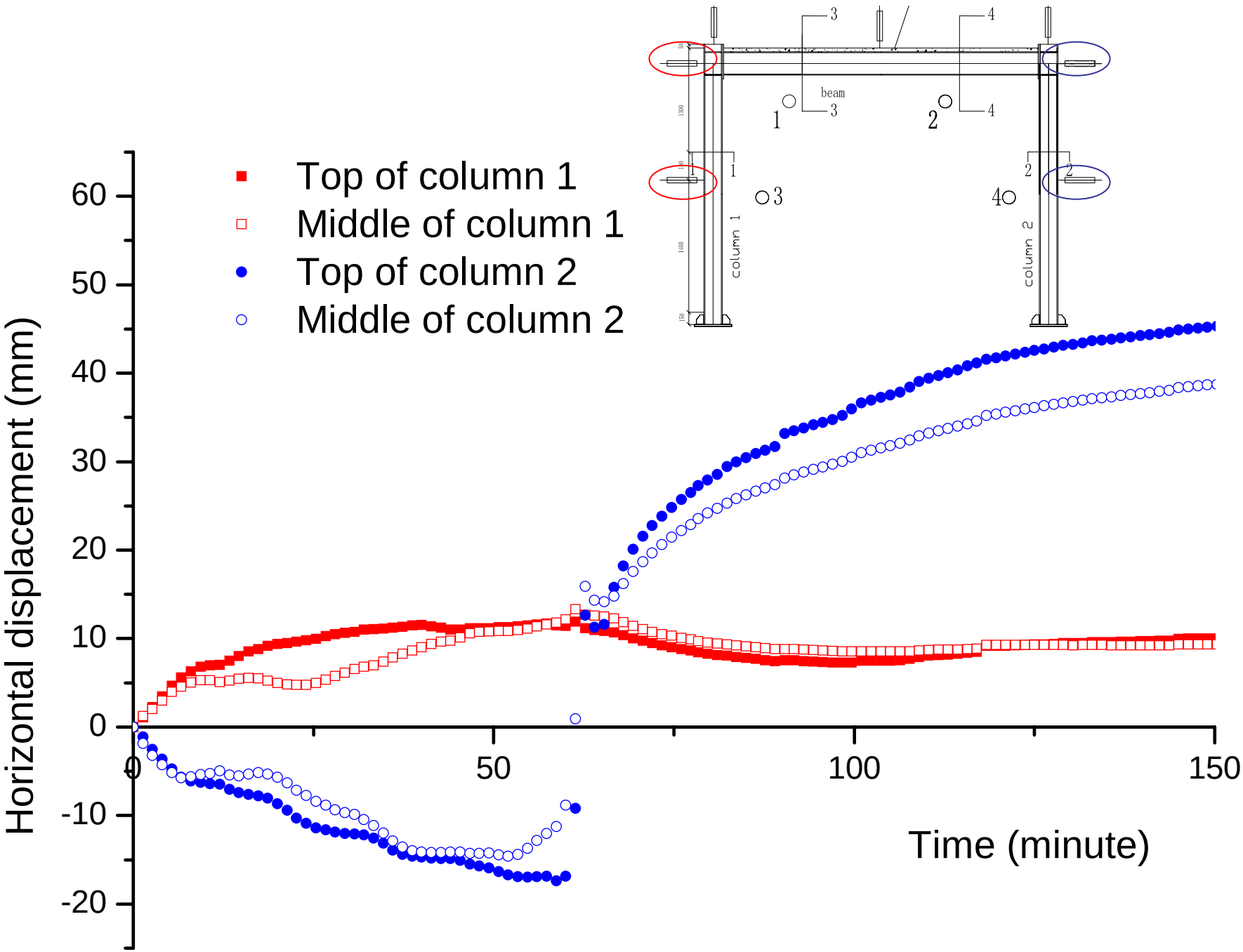
Composite beam cross-section Temperature vs. time.



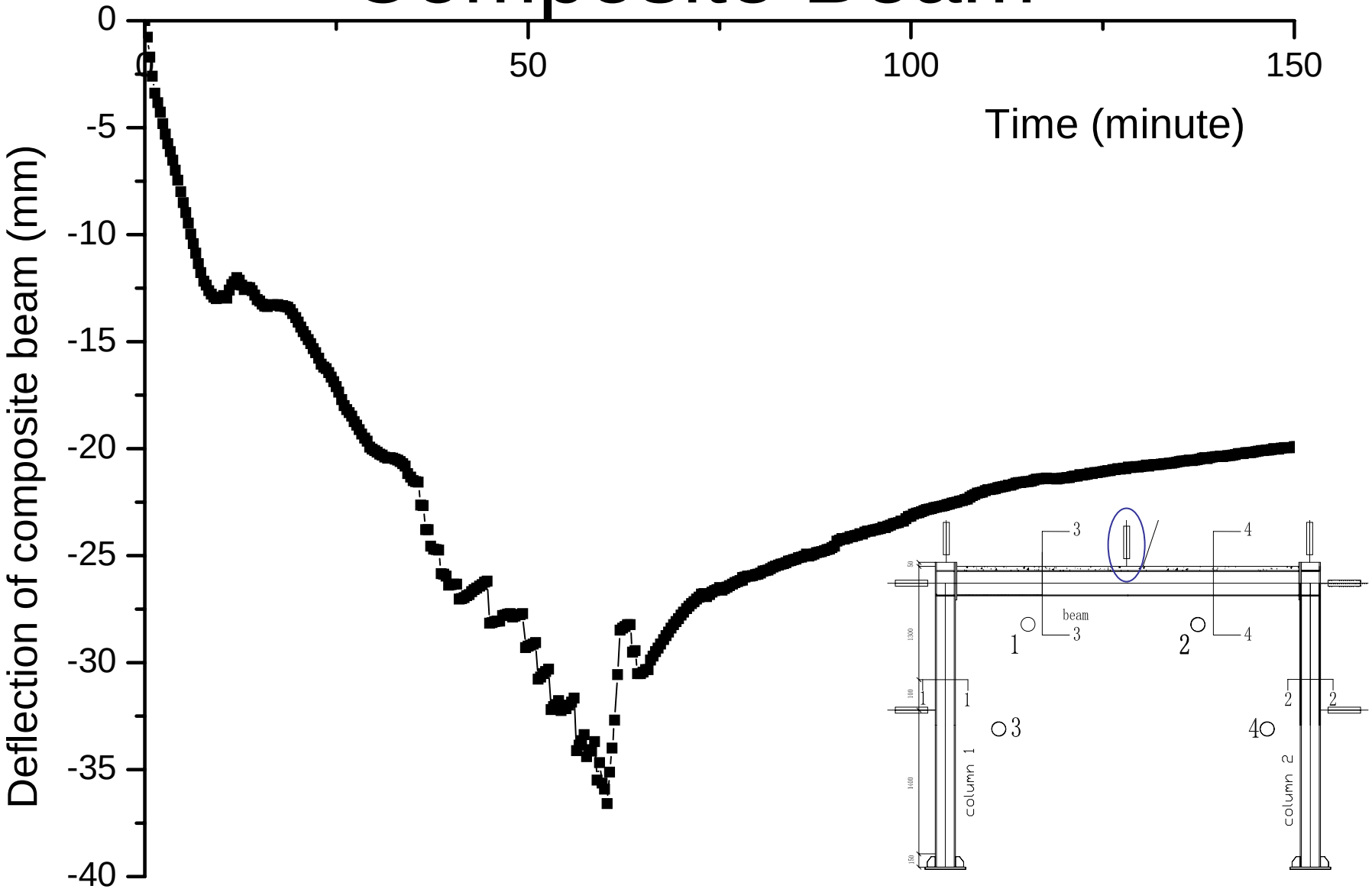
Steel Column cross-section Temperature vs. time.



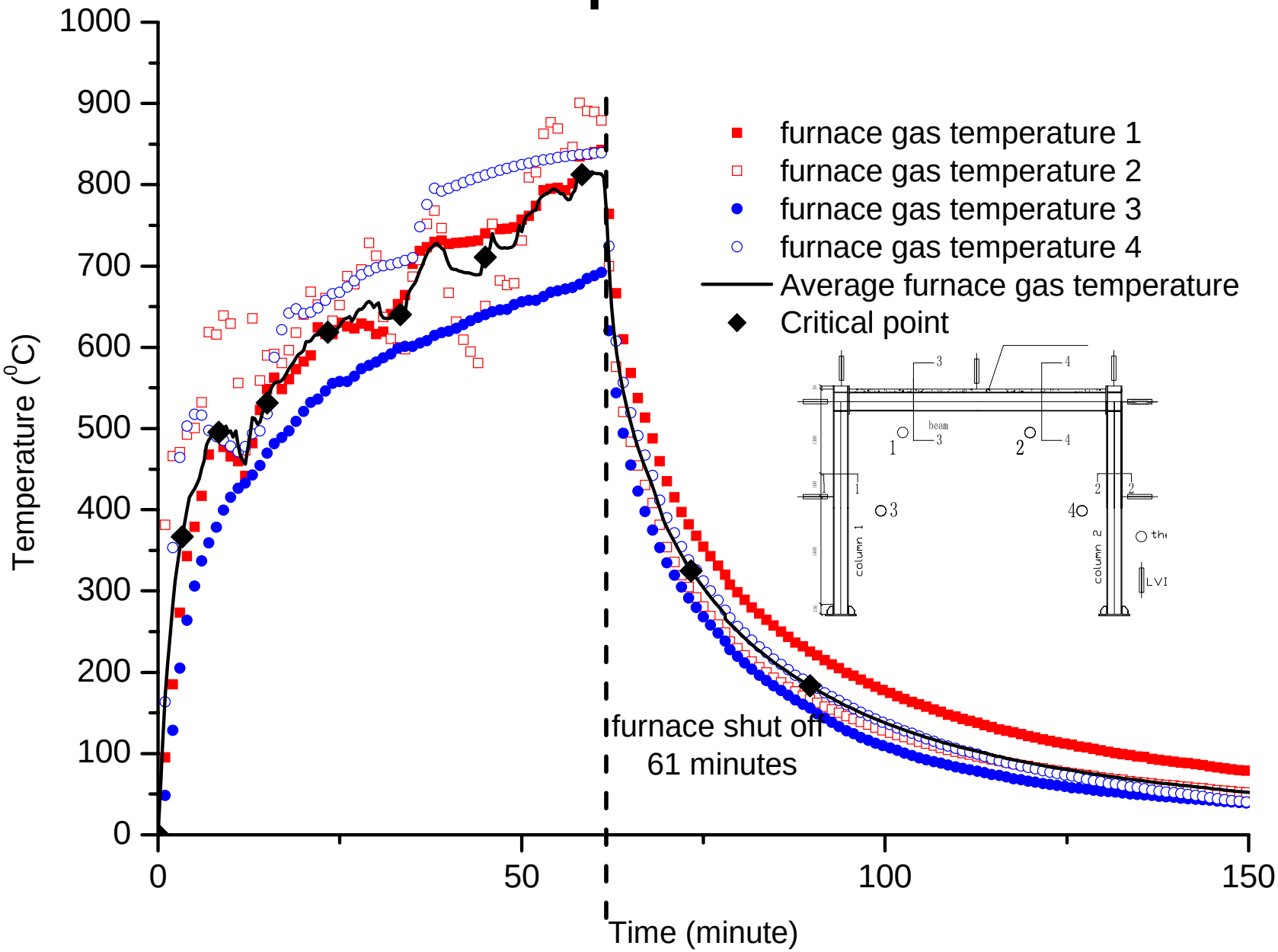

beam
column 1
column 2
Top of column 1
Middle of column 1
Top of column 2
Middle of column 2
Horizontal displacement(mm)
Average furnace gas temperature(0C)
60
50
40
30
20
10
0
-10
-20
0
200
400
600
800


Top of column 1
Middle of column 1
Top of column 2
Middle of column 2
Horizontal displacement (mm)
60
50
40
30
20
10
0
-10
-20
0
50
100
150
Time (minute)
beam
column 1
column 2

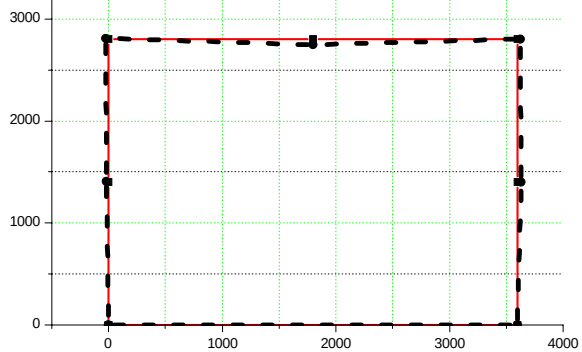
Vertical Deflection (mid-span) of Composite Beam



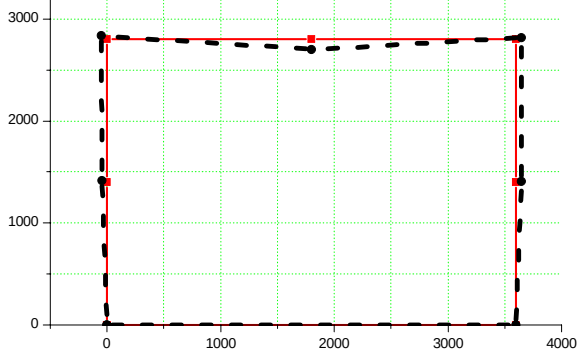
Furnace temperature vs. time



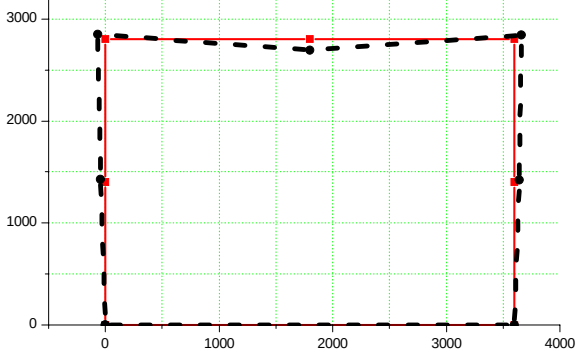
Deformation of the Test Frame : Heating and Cooling phase



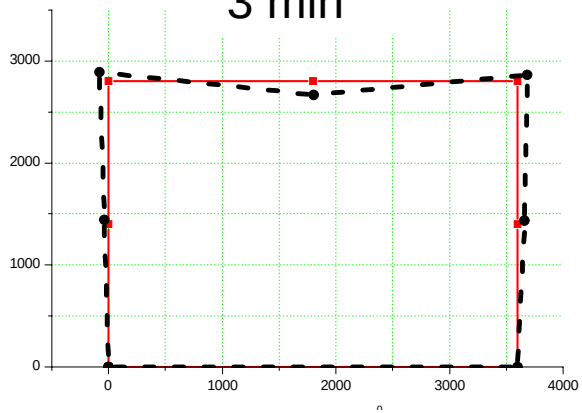
3 min



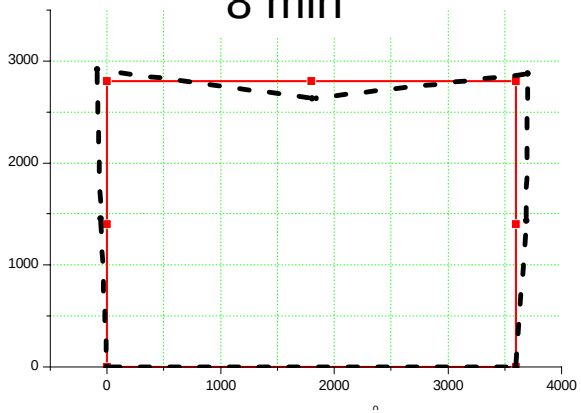
8 min



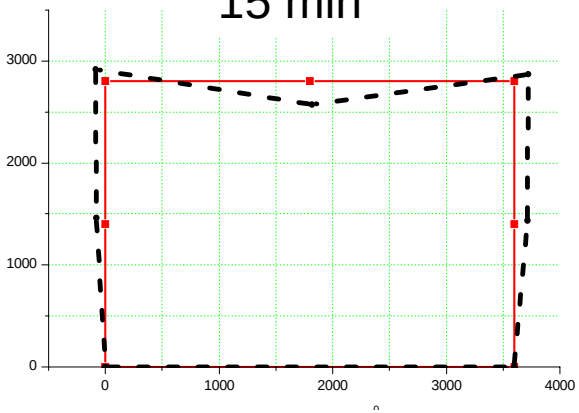
15 min



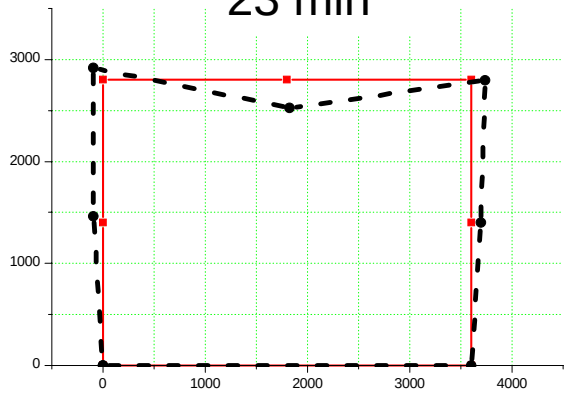
23 min



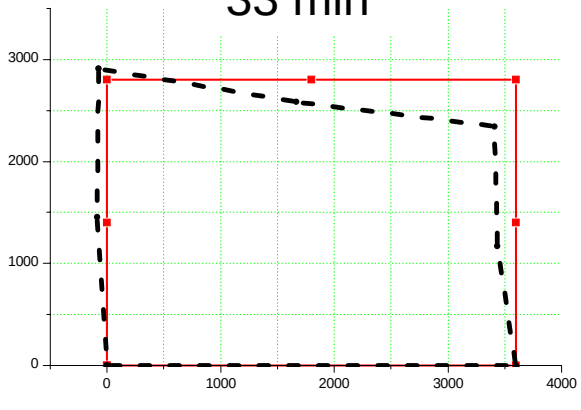
33 min



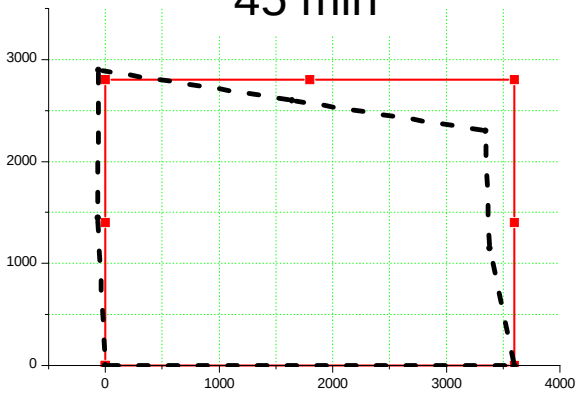
45 min



58 min



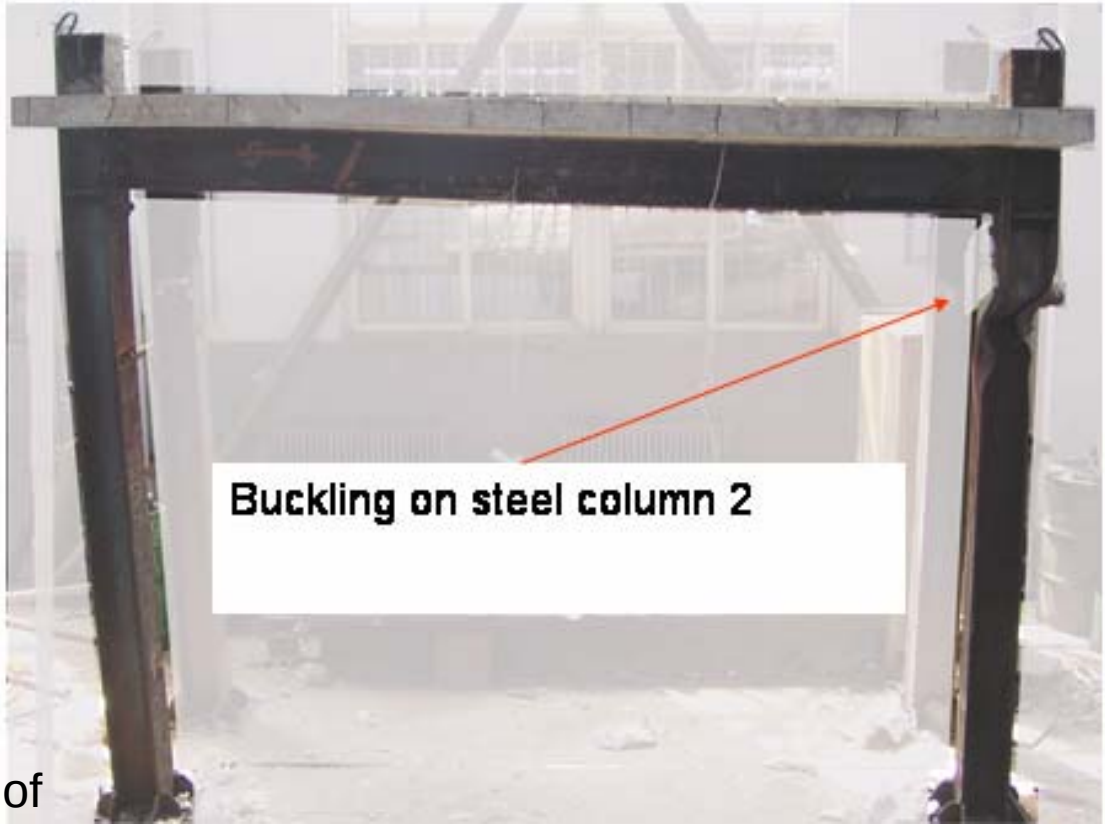
73 min



90 min

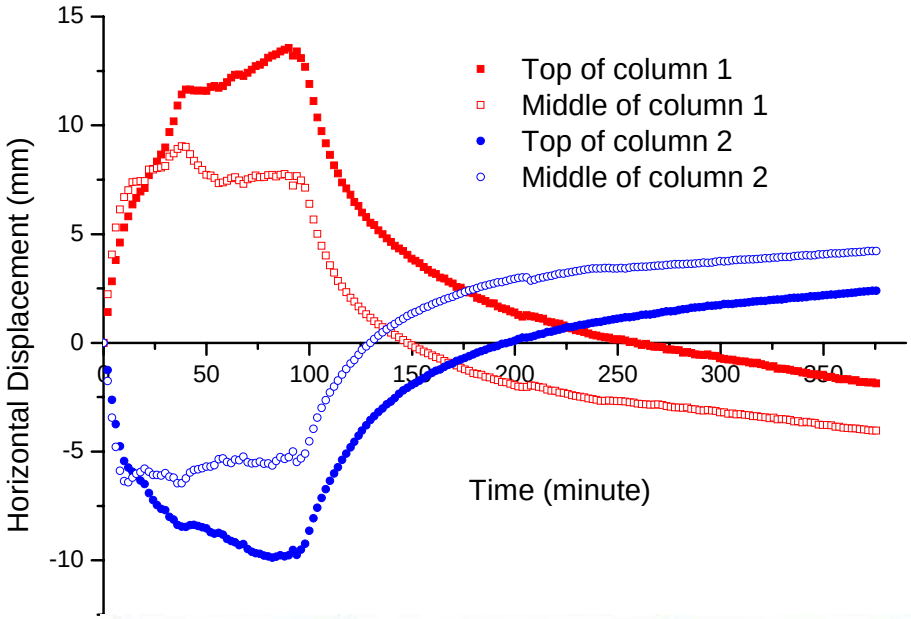
Post-test Visual Observation

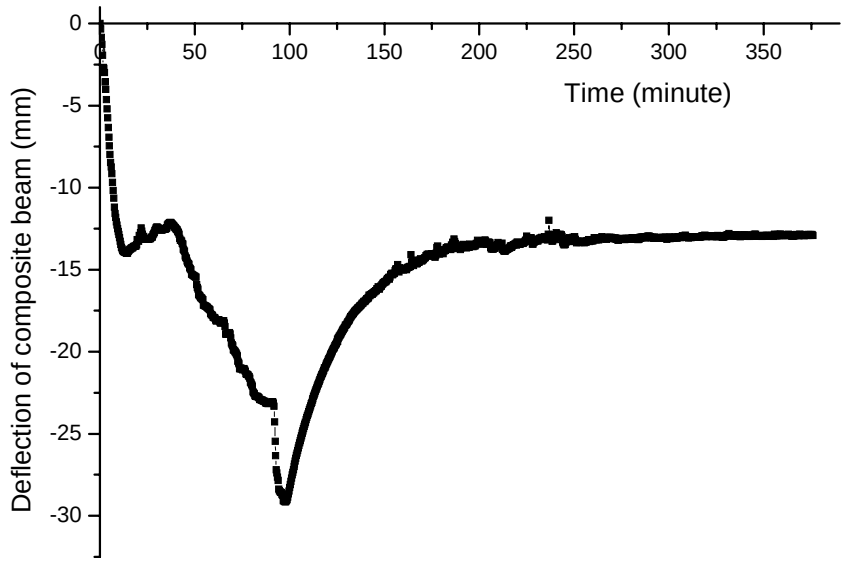
Outward bowing of Column 1



Cracks along the width of the concrete slab

Test 2


Horizontal Displacement (mm)
Time (minute)
Top of column 1
Middle of column 1
Top of column 2
Middle of column 2
15
10
5
0
-5
-10
50
100
150
200
250
300
350


Deflection of composite beam (mm)
Time (minute)
0
-5
-10
-15
-20
-25
-30
50
100
150
200
250
300
350


Local buckling of beam

Conclusions

- Furnace test on two full scale composite steel frames.
- Fire resistance of the composite beam was better than that of the column examined.
- Structural performance during cool down phase must be examined.
- Need for comprehensive modeling and analysis of the experiments to understand the structural response of frames.